Beta*, s* measurements
Spin tune versus closed orbit

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β* and s* measurements by Q1 gradient variation

$$\Delta Q = \frac{\langle \beta \rangle \Delta K l}{4\pi}$$

Change Q1 gradient -> measure betatron tune change -> extract quad beta function -> find β* and s* (using measurements from both Q1 quads)

$$\langle \beta \rangle = \langle m_{11}^2 \rangle \beta_0 - 2\langle m_{11} m_{12} \rangle \alpha_0 + \langle m_{12}^2 \rangle \gamma_0$$

$$\beta_0 = \beta^* + \frac{(L - s^*)^2}{\beta^*}; \quad \alpha_0 = -\frac{L - s^*}{\beta^*}; \quad \gamma_0 = \frac{1}{\beta^*}$$

$$\frac{L^2}{\beta^{*2}}; \quad \frac{L}{\beta^*}; \quad 1 \rightarrow$$

Terms hierarchy. For β* << L (~25m) the equations can be linearized by neglecting terms ~1.
However the linearization is not neccessary. The analytical solution of the system of two quadratic equations was found (for pp2pp lattice case, where β* ~ L)

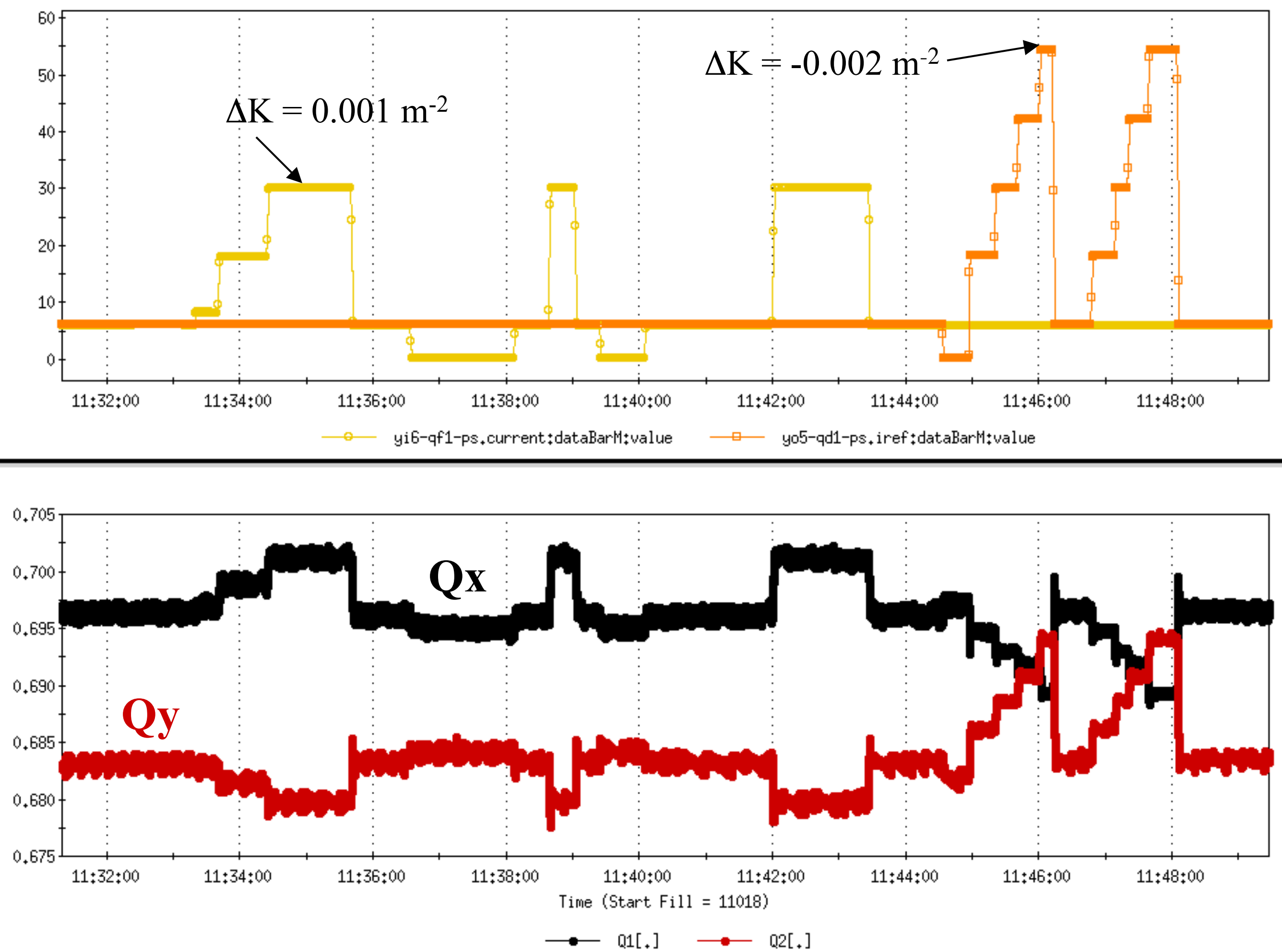
Notes on gradient variation method

- β^* and s^* measurements (both by gradient variation and with the use of AC-dipole) are not anymore APEX subject. It could be part of the machine operation setup.

- Although it is not one button push measurement. The machine should be prepared (well decoupled and well separated tunes) before the measurements to avoid the influence of betatron coupling on measured tune shifts.

- The analysis of the data for pp2pp run has been completed.

Measurements of beta* and s* in Yellow during pp2pp run



Results for pp2pp run

Table 1: IR6 β^* and s^* calculated from the Q1 gradient variation data.

	Blue ring	Yellow ring
β_x^*, m	19.3 ± 1.4	21.0 ± 2.2
s_x^*, m	4.36 ± 0.25	-4.36 ± 0.73
β_y^*, m	24.0 ± 3.2	17.4 ± 0.7
s_y^*, m	-4.93 ± 0.82	5.32 ± 0.24

Listed errors are on the basis of estimated accuracy of BBQ tune measurements and statistics

Table 2: IR6 β and α functions at interaction point (at $s = 0m$)

		Blue ring		Yellow ring	
		$\beta(0)$	$\alpha(0)$	$\beta(0)$	$\alpha(0)$
Horizontal	Measured	20.3	0.23	21.9	-0.21
	Design	22.3	0.17	21.8	-0.18
Vertical	Measured	25.0	-0.21	19.0	0.31
	Design	21.7	-0.19	21.1	0.22

Comparison of the design and measured optics parameters.
Design optics contains considerable alpha_0 (and therefore s*)

Spin tune versus closed orbit

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The experiment implementation will depend on whether the spin flipper is available.

With spin flipper we will scan the orbits (that is, change the orbit in steps) in definite locations and measure the spin tune using flipper.

Without the flipper we can put the vertical betatron tune closer to a spin resonance (0.75), then vary the orbit until the depolarization is observed. The orbit variation should be done in both (positive and negative) directions to identify the correct spin tune shift.

Following orbit variations are considered:

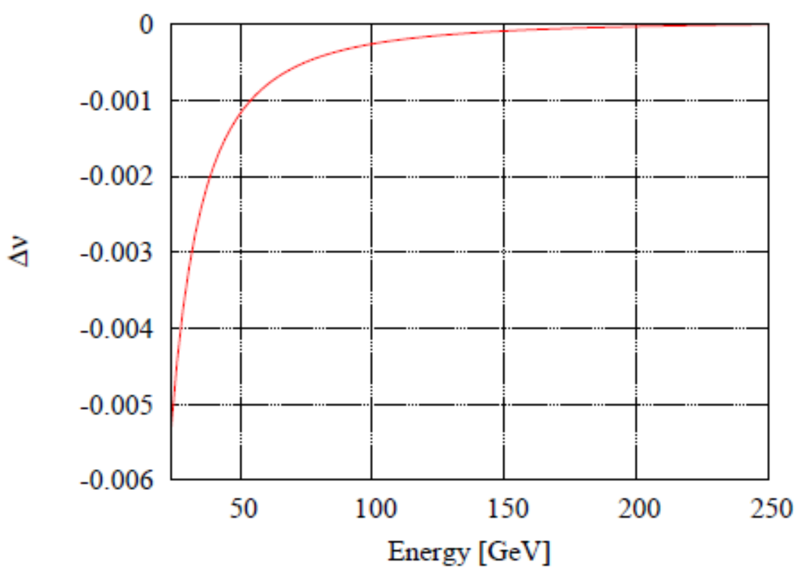
1) Variation of horizontal orbit angle at Snake locations at the injection energy. (This is most important effect).
2) Variation of vertical and horizontal orbit angles at the rotator locations. At the top energy with rotators on.
3) Variation of average radial orbit (by varying RF frequency). At the top energy.

Spin tune shifts

Due to horizontal orbit at rotators and snakes. Strong energy dependence.

$$\delta\nu_{sp} = \frac{1+G\gamma}{2\pi}\left(\Delta x'_{co\_rt1} + \Delta x'_{co\_rt2} + 2\Delta x'_{co\_sn}\right)$$

$$\Delta x'_{co\_rti} = x'_{co\_out} - x'_{co\_in}\,; \quad \Delta x'_{co\_sn} = x'_{co\_sn2} - x'_{co\_sn1}$$



Spin tune shift due to snakes also has energy dependence (Waldo's calculations)

$$\nu_{sp} = \frac{\left|\phi_1 - \phi_2\right|}{\pi}\cdot f(\gamma)$$

Run-9 measurements

- Measurements for spin tune dependence on the horizontal orbit angle at the snakes were done in both rings at different beam energies:

  at injection energy, at 100 GeV and at 250 GeV

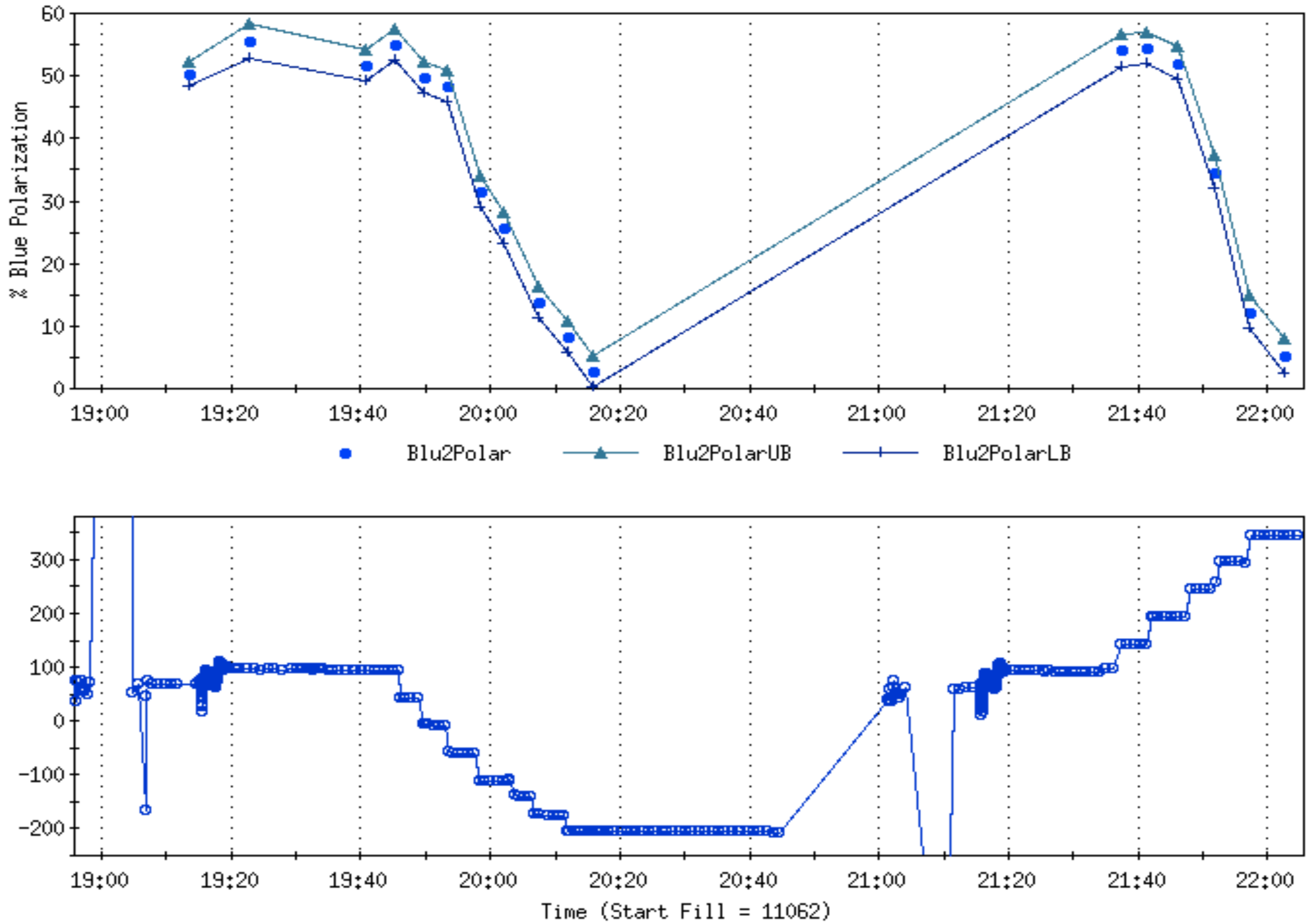
  These data sets will allow us to distinguish the contribution to the spin tune shift from snake imperfection and from horizontal angle between snakes.

- Also, few ramps were done with different snake orbit angles.

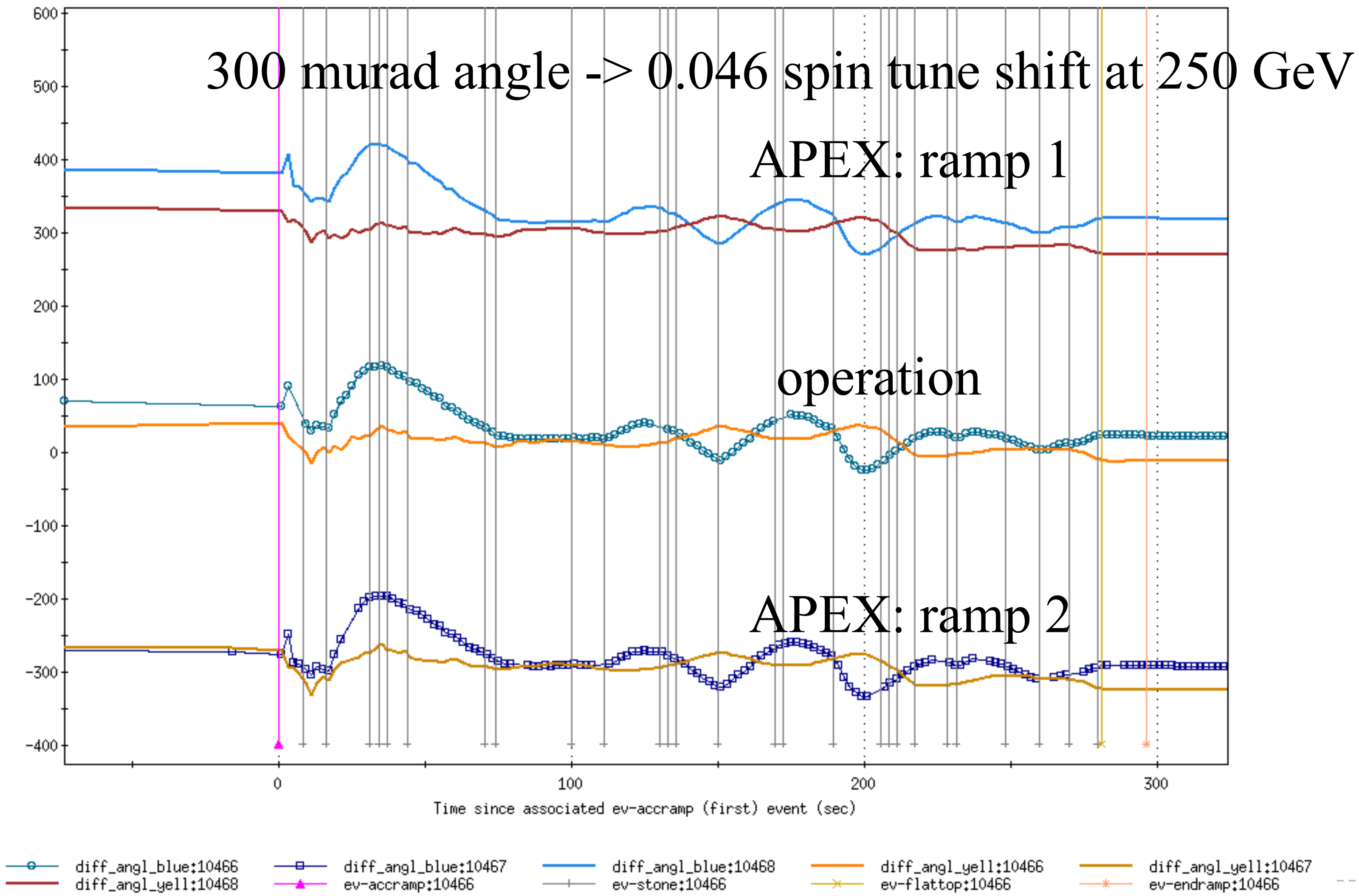
- Detailed data analysis is planned on January-February.

Spin tune as function of H orbital angle between snakes: measurements at the injection energy

Blue ring. Injection energy. Qy = 0.74



Orbit angle in snakes: ramp measurements

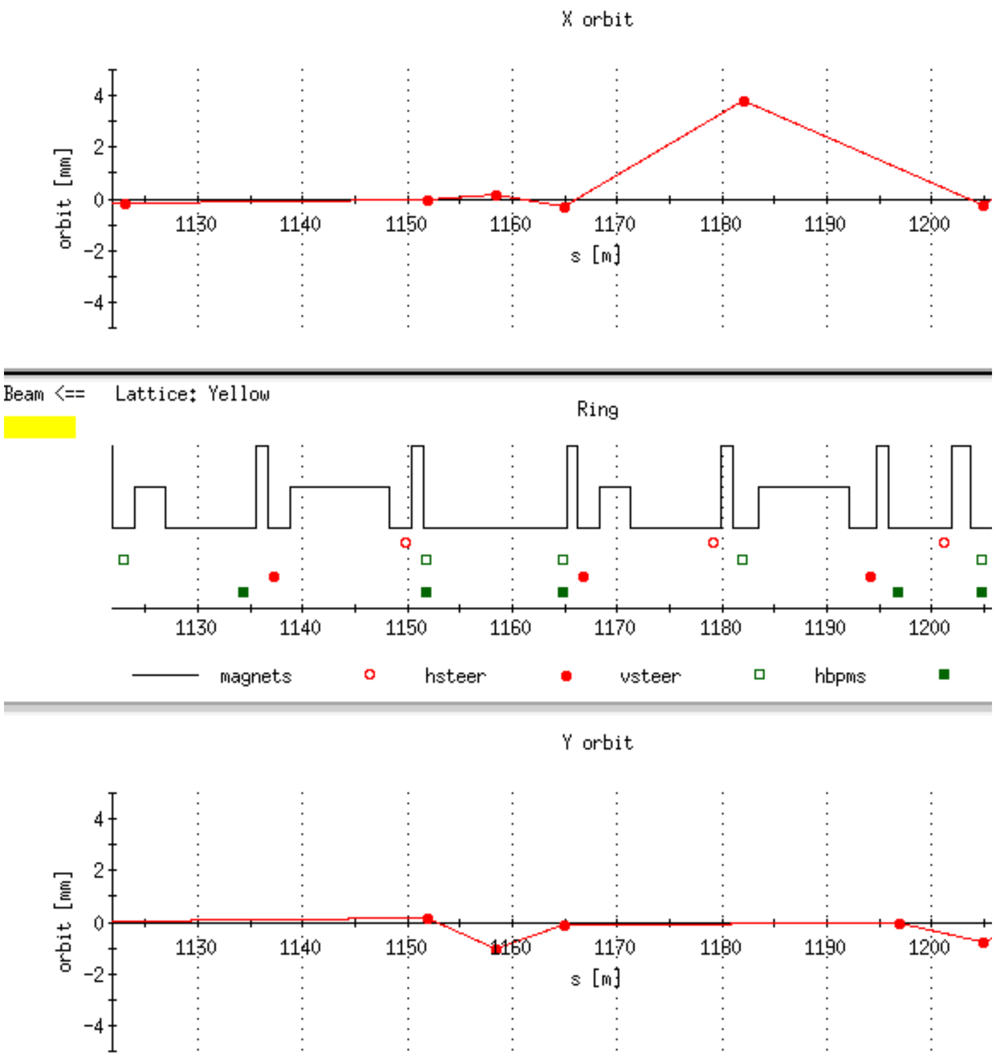


Polarization transmission on the ramp versus snake angle

Snake angle [mrad]	Blue at injection	err	Blue at store	err	Yellow at injection	err	Yellow at store	err
-0.3	58.4	3.7	53.8	3.7	63	3.2	16.4	4.2
-0.3			50.2	5			35.5	3.8
0.3	66.4	3.8	55.2	5	59.7	3.2	48.5	3.7

Stronger effect in Yellow.
Needs verification of measured polarization values from off-line analysis of polarimeter data.

Snake angle in Run-9



At 9 o'clock the zero orbit angle at snake location leads to few mm excursion at a neighboring location. In both rings.